ORC 80-3
FEBRUARY 1980

PROFICIENT ADAPTABLE RESPONSE TO EMERGENCIES CAUSED BY IDENTIFIABLE MALFUNCTIONS: CONTRASTING TRAINING IMPLICATIONS OF TWO PROPOSED MODELS

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(9) Research rept.,

(15) F4962φ-79-C-φφ63 (16) 2313 (17) A2

(11) FEB [redacted] 8φ (12) 22 (14) ØRC-8φ-3

This research was supported by the Air Force Office of Scientific Research (AFSC), USAF, under Contract F49620-79-C-0063 with the University of California. Reproduction in whole or in part is permitted for any purpose of the United States Government.

390150

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ORC 80-3	2. GOVT ACCESSION NO. AD-A084 451	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PROFICIENT ADAPTABLE RESPONSE TO EMERGENCIES CAUSED BY IDENTIFIABLE MALFUNCTIONS: CONTRASTING TRAINING IMPLICATIONS OF TWO PROPOSED MODELS		5. TYPE OF REPORT & PERIOD COVERED Research Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Hubert L. Dreyfus and Stuart E. Dreyfus		8. CONTRACT OR GRANT NUMBER(s) F49620-79-C-0063
9. PERFORMING ORGANIZATION NAME AND ADDRESS Operations Research Center University of California Berkeley, ~~California~~ 94720		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2313/A2
11. CONTROLLING OFFICE NAME AND ADDRESS United States Air Force Air Force Office of Scientific Research Bolling AFB, D.C. 20332		12. REPORT DATE February 1980 13. NUMBER OF PAGES 21
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Skill
Decision Aids
Situation Emergency Training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(SEE ABSTRACT)

Accession For	
NTIS GRA&I	
DDC TAB	
Unannounced	
Justification	
By	
Distribution/	
Availability Codes	
Dist.	Avail and/or special
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DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ABSTRACT

An adequate description of skill acquisition behavior must precede the design of training procedures. We presented such a description in Reference [1], identifying five developmental stages of mental activities involved in skill acquisition. Our model is applied here to the problem of training good judgment in a pilot's choice of recovery plan when faced by an emergency caused by an identifiable equipment malfunction. The training implications of our model contrast with the type of training procedure that would appear to follow from the model and recommendations of Perceptronics [3].

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I. INTRODUCTION

In Reference [1] we proposed a five-stage model of the mental activities involved in directed skill acquisition, and in Reference [2] we specifically applied an earlier version of this model to aircraft pilot emergency response behavior. Perceptronics has recently proposed a frame-based information processing model of emergency decision making [3] which, when applied to Situation 2 emergencies (defined below), seems conceptually similar to our model of expert behavior (Stage 4 of our model [1]). Both models emphasize the importance for understanding of seeing a situation from a perspective, and both acknowledge that attributes of a situation, when seen from a particular perspective, stand out with differing degrees of salience or importance.*

If the entire emergency problem faced by the pilot concerns the logi-- deduction of the nature of a mechanical malfunction from eit! ambiguous or complex cues, and the appropriate recovery plan is obvious once the malfunction has been deduced, we have no quar el with Perceptronics' proposed training procedures. As noted by the developers of Situational Emergency Training (SET), however, proficient emergency response depends not so much on mal-

*Perceptronics ([3], p. 7-25) explicitly acknowledges the phenomenon of relative salience with respect to malfunction cues, but does not mention this phenomenon when characterizing situation-dependent attributes. We have little doubt that they would acknowledge that relative salience also characterizes situation-dependent attributes.

function diagnosis, which is frequently obvious, as on the use of good judgment in choosing a recovery plan which takes account of such situational variables as mission profile, flight phase, weather, time of day, communications, distance from help, etc. Should judgment concerning an appropriate recovery plan be at issue, regardless of whether the malfunction diagnosis is obvious or complex, the training procedure suggested by our model would differ radically from the procedure that the application of the Perceptronics model to this type of problem would seem to suggest.

Before examining the competing training recommendations in more detail, let us describe three classes of emergencies as categorized in Reference [3]. After presenting this threefold typography of emergency situations our paper will deal exclusively with Situation 2 emergencies, which according to Perceptronics are most common.

Situation 1 emergencies "involve straightforward relationships between cues and malfunctions, information processing requirements are low, and response procedures are known and programmable" ([3], p. 7-36). Situation 2 emergencies, which elicit what are termed predictable, not programmed, responses by the authors of [3] involve "situations that can be foreseen, but for which decisions cannot be rigidly programmed because there are too many potential complexities that affect the decisions and the actions involved" ([3], p. 7-34). "Most emergencies that occur will fall into this category since most accidents that do take place are the result of repeated causes with known precedents but varying in situational detail" ([3], p. 7-35). "In Situation 3, cues can be complex, ambiguous and perhaps misleading" ([3], p. 7-36).

In Situation 1, we concur with Perceptronics that the pilot should be taught, by means of Boldface techniques, what to do. In Situation 3, the observed cues are not consistent with any familiar malfunction. Consequently, as Perceptronics recommends, creative hypothesis generation is called for. Hence, we devote this paper to Situation 2 emergencies, and the problem of training good judgment in the choice of a recovery plan.

II. OUR MODEL OF FIVE LEVELS OF MENTAL ACTIVITY INVOLVED IN EMERGENCY RESPONSE BEHAVIOR

Before examining in detail the frame-based information processing model of the cognitive process involved in the response to Situation 2 emergencies proposed by Perceptronics, let us briefly review our five-stage model presented in [1].

Normally, the instruction process begins by decomposing the task environment into context-free features which the beginner can recognize without benefit of experience. The beginner is then given rules for determining an action on the basis of these features. For example, the novice pilot is taught the proper sequence of actions, as a function of altitude, should the engine fail.

Competence, Stage 2, comes only after considerable experience actually coping with real situations in which the student notes or an instructor points out recurrent meaningful component patterns. These situational components, in terms of which a competent student understands his environment, are no longer the context-free features used by the novice. The instructor formulates principles, called guidelines, dictating actions in terms of these components. The guidelines treat all such components as equally important and are formulated so as to integrate as many as possible. A competent pilot, suffering the failure of one of his two engines, will consider strange noises and vibrations in the second engine, unfamiliar and confusing landing patterns at the nearest base, etc. in choosing his recovery plan.

Increased practice enables a performer to reach Stage 3, proficiency. He acquires a repertoire of typical meaningful whole situations, and he perceives his current situation as not only having components, but from a perspective which leads some components to stand out as crucial while others receed into the background. He acquires maxims which, given a particular perspective, dictate the appropriate action. For the first time, borderline situations can occur in which the appropriate perspective is in question. For example, a pilot, experiencing minor engine problems, may see the existence of appropriate repair facilities at his home base as salient, and proceed there rather than land at a closer, but less well equipped, base. In a borderline situation, however, as we will discuss in more detail later, he may be torn between the above perspective and one seeing an intervening weather front as more crucial than repair considerations.

The expert performer in a particular task environment has reached Stage 4, the final developmental stage in the step-wise improvement of mental processing which we have been following. His repertoire of experienced specific situations has become so vast that normally each situation immediately dictates an intuitively appropriate action. His actions are no longer analytically calculated using principles operating on components, but are directly associated with typical situations. The expert pilot responds to an emergency with an appropriate action, without any awareness of reasons for choosing that action.

The highest level of performance, called mastery, comes during moments when the expert is totally absorbed in his work. All conscious monitoring of his activities cease, and his performance transcends even its usual high level. A pilot, responding in a masterful way in an emergency, is not conscious, until the emergency is over, of the gravity of the emergency and the subtlety of his response.

III. THE PERCEPTRONICS MODEL OF COGNITIVE PROCESSES

We now describe the form that we believe the Perceptronics model would take if applied to Situation 2 emergencies with identifiable malfunctions but a complex pattern of situational detail. According to [3], as experience accumulates, long-term memory comes to consist of numerous representational systems, each consisting of a meaningful cluster of related information. Associated with those representations are templates which are preplanned responses which can only be activated when the pattern of environmental stimulae matches all the elements in the representational system. Normally, relevant attributes of the environment are perceived through the perspective of the currently active representational system, and these attributes either confirm the appropriateness of the current representational system or the most salient attribute activates a different more appropriate representation. The difficulty, when emergencies of the type being considered here occur, is that the current perspective becomes inappropriate, and current attributes may be used to call up several alternative representations. If they are so used, then integration of the information from these alternative perspectives becomes necessary. Since each perspective has its own associated preplanned response, no single appropriate response presents itself, and rules for selecting the best decision are required.

To sharpen the reader's understanding, and make clear our interpretation in order to allow correction if we have misunderstood the Perceptronics picture, let us now analyze a certain emergency in terms of this model. Consider a simplified version of a Perceptronics case study ([3], pp. A1-A13). A Navy pilot experiences a specific diagnosable engine malfunction. (In the actual case studied, the malfunction was not easily diagnosed. We have made this simplifying change so that only the response is in question and not also the nature of the malfunction.) The nearest landing field is Air Force Base A with unfamiliar and confusing landing patterns. Somewhat further away in a different direction is Air Force Base B without this disadvantage. Equally as far away as B in yet another direction is the pilot's home base with its appropriate Navy maintenance facilities. However, a bad weather front is located between the pilot and his home base. Once distance has been taken into account, interpretation of the objective situation by seeing any two of the above three factors as more salient than the third, dictates a different decision. Attending to weather and landing pattern problems dictates proceeding toward Base B. Focusing on the maintenance facilities and landing pattern problems leads to flight toward the pilot's home base. Singling out the conflicting maintenance and weather considerations at his home base, while diverting concern from Base A's landing pattern problems, makes Base A the most attractive.

Since the three perspectives dictate different and contradictory responses and since each perspective leaves one objective factor out of consideration, Perceptronics recommends an integration of these several cognitive representational systems. Presumably in the above example, this means that maintenance facilities, weather, and landing pattern difficulties should *all* be considered along with distance.*

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*Perceptronics further recommends template integration, i.e., some combining of the three conflicting decisions, each of which is the appropriate preplanned response to one interpretation of the objective situation. (See "Situation 2, Cognitive Processes" entry in the Table on p. 7-37 of [3].) What that would mean with respect to the above example is unclear. At other places in [3] integration of the representational systems, i.e., some combining of the facts seen as relevant in differing perspectives, is advocated. (See [3], p. 7-34 bottom and 7-35 top and discussion of Situation 2 training on p. 7-36.) It is this recommendation that we shall treat in the next section.

IV. PROBLEMS RAISED BY THE PERCEPTRONICS MODEL

On the face of it, the Perceptronics model extended to cover situational attributes seems remarkably similar to our model of the fourth stage of skill acquisition--expertise [1]. Both would start with the observation that a pilot in normal flight will be perceiving his situation through an appropriate perspective. When abruptly there is evidence that a specific malfunction has occurred, he must radically change this perspective. Attributes which were irrelevant to him before the malfunction, such as the terrain beneath him, the location of nearby air bases, etc., suddenly become important. Which of the vast number of potentially relevant environmental facts are seen as crucially important will determine which action he takes. On the basis of past experience, different sets of attributes with differing salience profiles suggest themselves, and each has associated with it an unambiguous appropriate response.

What should the pilot do to make the most of this flood of possibly relevant perspectives? The Perceptronics recommendation, it appears, would be that, before deciding on an action, the pilot should construct an integrated set of environmental attributes by taking the union of the sets of attributes produced by viewing the emergency under each of the flood of possibly relevant perspectives which the emergency originally invoked. It would seem that all the facts in this integrated set must be seen as equally salient because the same fact has very different saliences when viewed through different perspectives. For example, in our hypothetical emergency in Section III, facts such as the weather front located between the pilot and his home base can be anything from irrelevant to maximally salient, depending upon the perspective from which the emergency is viewed. (Even if one particular attribute is salient in all the available perspectives, all other attributes will have saliences which vary with the differing perspectives, and in the integration these variations will have to be flattened.) Presumably, if training was conducted as Perceptronics recommends, a maxim or decision procedure which can be used to calculate an appropriate action once the environmental facts are specified is associated through training with this representational system.

Such a proposal as to how pilots should be trained to cope with emergencies would have three drawbacks. First, according to our research [1], behavior based on the application of decision procedures is characteristic of proficient, as distinguished from higher level expert, performance. Consequently, starting from the presumption that the pilot has the sort of narrowly defined perspectives with associated templates which produce expert performance, a training procedure producing regression to proficiency, an inferior level of emergency response, would result.

Second, considerations based on Gestalt theory suggest that the quality of the pilot's performance might well even fall below the level described as proficient in [1]. The proficient performer is assumed to be seeing his situation through a broadly defined perspective so that the facts are already organized in such a way that each has its own degree of salience. As indicated above, the integration of perspectives presumably amounts to arbitrarily assigning equal salience to all those facts whose salience differs with differing perspectives. This equalizing of saliences is characteristic of what we called competent behavior and can result in loss of information as can be seen in the case of the Necker cube (Figure 1).

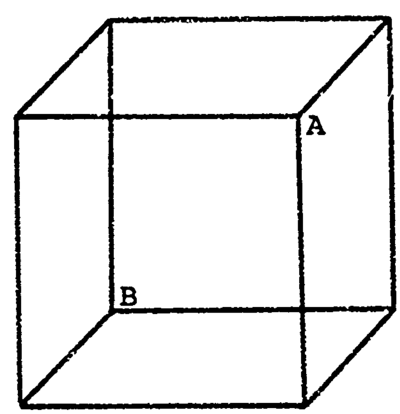

FIGURE 1

If a person experienced with cubes focuses on vertex A, thus seeing it as salient and reducing vertex B to the background, he sees a three-dimensional cube with vertex A projecting forward from the plane of the paper. Similarly, focusing on vertex B causes the observer to see a three-dimensional cube in reverse projection. If, however, the viewer succeeds with some effort in seeing all vertices as equally salient (or nonsalient, which comes to the same thing) he sees only a flat pattern of vertical, horizontal, and diagonal lines. All information about cubes, such as how many surfaces they have and how you have to move to get from one to another, has been annihilated. In this extreme case, all skillful activity involving cubes becomes impossible.

The Necker cube illustrates the essential figure-background structure of perception pointed out by Merleau-Ponty [4]. This characteristic applies equally to all situational understanding, [5]. Since an important part of our understanding of a situation with which we are familiar is embodied in the relative degree of salience of the attributes, arbitrary equalizing of salience necessarily results in a loss of understanding.

The third drawback is that, since the pilot is hypothesized to be experienced, he must struggle to remain detached, constantly resisting his acquired tendency to view his situation from one of the already tested specific action-oriented perspectives flooding his mind. Faced with an emergency, the tension between the striving for detachment produced by training and the tendency to become involved produced by experience, could lead to a dangerous oscillation between stances and hence responses.

The question remains: how can the pilot, while remaining involved in one perspective so as to avoid regression, make use of the information contained in other contrasting perspectives and yet avoid oscillation?

V. A RECOMMENDED ALTERNATIVE TRAINING PROCEDURE

For a clue to the solution of this puzzle, let us review Thomas Kuhn's seminal account of how scientists acquire knowledge [6]. According to Kuhn, science does not proceed by the detached accumulation of facts about the world, nor by making hypotheses and then checking them against the available neutral data. Rather, scientists are trained into and tacitly accept a certain model (perspective or paradigm) which dictates what counts as facts and their degree of relevance. Facts which do not fit into this perspective are viewed by the typical scientist as anomalies which pose problems for research. If these facts resist being fitted into the current paradigm, they are eventually ignored by the everyday scientist. Ultimately, a truly creative scientist, who has been operating proficiently within the accepted paradigm without, however, suppressing the unexplained phenomena, produces a new paradigm in which what were anomalies in the old paradigm are explained and shown to be centrally important from the new perspective, while some of what seemed important from the old perspective is now seen as irrelevant. The change from the Ptolemaic to the Copernican view of the universe is a spectacular example of such a Gestalt switch.

Like the creative scientist, what the expert pilot needs is to be both decisive and open-minded. If the pilot has had enough experience to have refined his perspectives to the point that they are reliable, any of the perspectives flooding his mind from the past is a plausible way of appraising and reacting to the situation. If *one* of the perspectives imposes itself with overriding urgency, he should trust his experience-based instinct and respond from that point of view. If several perspectives present themselves with equal urgency, he should decisively choose any one and interpret events through it. In either case, he should not imitate the everyday scientist by trying to suppress attributes which do not fit, or interpret them in inger'ous but implausible ways. Rather, while persisting resolutely in one perspective, he should be receptive to "unimportant" attributes which, if enough of them accumulate, should be allowed to call up a different perspective from which they can be seen as important. If, under these conditions, circumstances force him to abandon a perspective on the basis of evidence *that perspective itself* reveals, that perspective will no longer tempt indecision by competing for his attention.

The above considerations lead us to the following trainin recommendations for types of emergencies in which the specific malfunction is obvious but the complexity of situational details precludes Boldface-type training.

(1) If a single interpretation of the environmental attributes presents itself, the pilot should be trained to continue to view and respond to the situation under that interpretation while nonetheless remaining receptive to attributes which tend to undermine that interpretation. He should be trained to be willing to switch to another recovery

plan when the preponderance of facts *viewed from within his initial perspective* are incompatible with that perspective.

(2) If several interpretations of the environmental attributes seem equally urgent, the pilot should be trained to arbitrarily and decisively choose one and proceed as in (1) above. From within the chosen perspective, the facts and the associated recovery plan will no longer appear ambiguous. This will avoid response oscillation.

The ability to stay involved thus taught enables the pilot both to act decisively and to remain responsive to new information. It thus has all the advantages of responsiveness to the overall situation which might seem to be gained from detachment, while avoiding the loss of understanding and the degradation of performance inherent in detached analysis.

VI. SUMMARY

Before designing training programs and aids, it is essential that one have an adequate description of skill acquisition behavior. The first step is then to specify, explicitly and unambiguously, which developmental state the student is presumed to have attained at the commencement of the training. Only then does it become clear what mental capacities he has acquired so that the training can build from there towards the next stage, and avoid the temptation to introduce intricate and sophisticated decision aids which, were the student at a lower level, would improve his performance, but which, given the actual level of the student, would encourage regression. Our model suggests that the Perceptronics training procedures, if extrapolated to the type of emergency response problem that motivated the development of SET, would assume a high level of skill which we call expertise, but would result in a lower level of skill, either what we call proficiency or competence.

REFERENCES

[1] Dreyfus, Stuart E. and Hubert L. Dreyfus, "A Five-Stage Model of the Mental Activities Involved in Directed Skill Acquisition," ORC 80-2, Operations Research Center, University of California, Berkeley, (1980).

[2] Dreyfus, Stuart E. and Hubert L. Dreyfus, "The Scope, Limits, and Training Implications of Three Models of Aircraft Pilot Emergency Response Behavior," ORC 79-2, Operations Research Center, University of California, Berkeley, (1979).

[3] Hopf-Weichel, Rosemarie, et al., "Aircraft Emergency Decisions: Cognitive and Situational Variables," Perceptronics Technical Report PATR-1065-79-7, (1979).

[4] Merleau-Ponty, Maurice, PHENOMENOLOGY OF PERCEPTION, Routledge and Kegan Paul, London, England, p. 4, (1962).

[5] Merleau-Ponty, Maurice, THE PRIMACY OF PERCEPTION, Northwestern University Press, Evanston, Illinois, pp. 12-27, (1964).

[6] Kuhn, Thomas, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS, Second Edition, University of Chicago Press, (1970).